I, the undersigned, who have prepared English translation which is attached herewith, hereby declare that the aforementioned translation is true and correct translation of officially certified copy of the Korean Patent Application No. 10-2003-0082563 filed on November 20, 2003.

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Date: September 8, 2010

KOREAN INTELLECTUAL PROPERTY OFFICE

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Date of Application:	November 20, 2003
Application Number:	Patent Application No. 10-2003-0082563
Applicant(s):	SAMSUNG ELECTRONICS CO., LTD.

COMMISSIONER

APPLICATION FOR PATENT

To the Commissioner of
the Korean Intellectual Property Office

FILING DATE: November 20, 2003

TITLE: APPARATUS AND METHOD OF CONVERTING IMAGE SIGNAL FOR SIX COLOR DISPLAY DEVICE, AND SIX COLOR DISPLAY DEVICE HAVING OPTIMUM SUBPIXEL ARRANGEMENT

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Submitted herewith is an application identified above pursuant to Article 42 of the Patent Act.

[ABSTRACT OF THE DISCLOSURE]

[ABSTRACT]

The present invention relates to a six color flat panel display, and more particularly relates to a flat panel display having a optimum six subpixels arrangement.

A display device according to an exemplary embodiment of the present invention includes a plurality of pixel arranged in matrix, each pixel including first and second sets of three primary color subpixels, wherein the subpixels are arranges so that two subpixels having complementary relation is adjacent to each other, wherein the subpixels are arranged in a 2X3 matrix or a 3X2 matrix, wherein the first set of three primary color subpixels are arranged in a row or a column, and the second set of three primary color subpixels are arranged in a row or a column. Preferably, a subpixel having the lowest luminance is disposed at a side.

Accordingly, the six-color subpixel arrangement may prevent the color error that appears near edges of characters and can reproduce an image that approaches the original image.

[REPRESENTATIVE DRAWING]

Fig. 3a

[INDEX]

Pixel, Subpixel, Color coordinates, Red, Blue, Green, Cyan, Magenta, Yellow, Luminance, Color filter, Transmittance, Flat panel display

[SPECIFICATION]

[TITLE OF THE INVENTION]

SIX COLOR FLAT PANEL DISPLAY

[BRIEF DESCRIPTION OF THE DRAWINGS]

Fig. 1 is a block diagram of an LCD according to an embodiment of the present invention.

Fig. 2 is an equivalent circuit diagram of a subpixel of an LCD according to an embodiment of the present invention.

Fig. 3a-3c show arrangements of six six-color subpixels of an LCD according to embodiments of the present invention.

Figs. 4a and 5a illustrate oblique lines displayed by the subpixel arrangement shown in Fig. 3a, and Figs. 4b, 4c and 5b illustrate oblique lines displayed by the subpixel arrangement shown in Fig. 3b.

Figs. 6a-6h and 7a-7h show subpixel arrangements modified from those shown in Figs. 3a and 3b, respectively.

Fig. 8a-8d shows subpixel arrangements according to other embodiments of the present invention.

Figs. 9a and 9b illustrate oblique lines displayed by the subpixel arrangement shown in Figs. 8a and 8b.

Fig. 10 shows the luminance variation depending on the variation of magenta.

[DETAILED DESCRIPTION OF THE INVENTION]

[OBJECT OF THE INVENTION]

[FIELD OF THE INVENTION AND PRIOR ARTS OF THE FIELD]

The present invention relates to a six color flat panel display, and more particularly relates to a liquid crystal display having six-color subpixels.

Recently, flat panel displays such as organic light emitting displays, plasma display panels, and liquid crystal displays are widely developed.

The plasma display panel (PDP) is a device which displays characters or images using plasma generated by a gas-discharge, and the organic light emitting display (OLED) is a device which displays characters or images by applying an electric field to specific light-emitting organics or high molecule materials.

The liquid crystal display (LCD) is a representative of the flat panel displays. The LCD includes a liquid crystal (LC) panel assembly including two panels provided with two kinds of field generating electrodes such as pixel electrodes and a common electrode and a LC layer with dielectric anisotropy interposed therebetween. The variation of the voltage difference between the field generating electrodes, i.e., the variation in the strength of an electric field generated by the electrodes changes the transmittance of the light passing through the LCD, and thus desired images are obtained by controlling the voltage difference between the electrodes.

The flat panel display includes a plurality of pixels including three sub-pixels representing red, green and blue colors.

[PROBLEMS TO BE SOLVED OF THE INVENTION]

However, the three primary color system has a limit for some ranges of

colors such as high concentration cyan. This may be overcome by using cyan as one of primary colors. However, the addition of cyan may decrease the luminance of the display device. In order to solve this problem, magenta and yellow as well as cyan are added to primary colors to form a six primary color system.

However, the conventional six-color display device has a color fringe error that a color is recognized near edges of the small characters. In addition, the displayed images may have spots.

Moreover, the luminance is required to be increased.

[STRUCTURES OF THE INVENTION]

In order to solve the object, a display device according to an exemplary embodiment of the present invention includes includes: a plurality of pixel arranged in matrix, each pixel including first and second sets of three primary color subpixels, wherein the subpixels are arranges so that two subpixels having complementary relation is adjacent to each other. The subpixels may be arranged in a 2X3 matrix or a 3X2 matrix. The first set of three primary color subpixels may be arranged in a row or a column, and the second set of three primary color subpixels may be arranged in a row or a column. A subpixel having the lowest luminance may be disposed at a side. Three subpixels having relatively high luminance may be distributed over different rows or columns. The three high-luminance subpixels may be distributed over two rows or two columns.

The three high-luminance subpixels may be arranged symmetrically in a row or column direction. Two subpixels having relatively high luminance may

be arranged in a diagonal.

The first or the second set of three primary color subpixels may include a white subpixel. The first set of three primary color subpixels may include red, green and blue subpixels, and the second set of three primary color subpixels may include cyan, magenta, and yellow subpixels. The first set of three primary color subpixels may include red, green and blue subpixels, and the second set of three primary color subpixels may include cyan, white, and yellow subpixels.

The subpixels may be arranged in a 2X3 matrix or a 3X2 matrix. The first set of three primary color subpixels may be arranged in a row or a column, and the second set of three primary color subpixels may be arranged in a row or a column. The blue subpixel may be disposed at a side and the green subpixel may be disposed at a center. The green, cyan, and yellow subpixels may have luminance higher than other subpixels.

The green subpixel may be disposed at a side. The green and yellow subpixels may have luminance higher than other subpixels.

The present invention will be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. As those skilled in the art would realize, the described embodiments may be modified in various different ways, all without departing from the spirit or scope of the present invention.

In the drawings, the thickness of layers, films, panels, areas, etc., are exaggerated for clarity. Like reference numerals designate like elements throughout the specification. It will be understood that when an element such

as a layer, film, area, or substrate is referred to as being "on" another element, it can be directly on the other element or intervening elements may also be present. In contrast, when an element is referred to as being "directly on" another element, there are no intervening elements present.

An LCD according to an embodiment of the present invention will be described in detail with reference to accompanying drawings.

Fig. 1 is a block diagram of an LCD according to an embodiment of the present invention, and Fig. 2 is an equivalent circuit diagram of a subpixel of an LCD according to an embodiment of the present invention.

Referring to Fig. 1, an LCD according to an embodiment includes a LC panel assembly 300, a gate driver 400 and a data driver 500 that are connected to the panel assembly 300, a gray voltage generator 800 connected to the data driver 500, and a signal controller 600 controlling the above elements.

Referring to Fig. 1, the panel assembly 300 includes a plurality of display signal lines G1-Gn and D1-Dm and a plurality of subpixels connected thereto and arranged substantially in a matrix. In a structural view shown in Fig. 2, the panel assembly 300 includes lower and upper panels 100 and 200 and a LC layer 3 interposed therebetween.

The display signal lines G1-Gn and D1-Dm are disposed on the lower panel 100 and include a plurality of gate lines G1-Gn transmitting gate signals (also referred to as scanning signals), and a plurality of data lines D1-Dm transmitting data signals. The gate lines G1-Gn extend substantially in a row direction and substantially parallel to each other, while the data lines D1-Dm extend substantially in a column direction and substantially parallel to each

other.

Each subpixel includes a switching element Q connected to the signal lines G1-Gn and D1-Dm, and a LC capacitor CLC and a storage capacitor CST that are connected to the switching element Q. If unnecessary, the storage capacitor CST may be omitted.

The switching element Q including a TFT is provided on the lower panel 100 and has three terminals: a control terminal connected to one of the gate lines G1-Gn; an input terminal connected to one of the data lines D1-Dm; and an output terminal connected to both the LC capacitor CLC and the storage capacitor CST.

The LC capacitor CLC includes a pixel electrode 190 provided on the lower panel 100 and a common electrode 270 provided on an upper panel 200 as two terminals. The LC layer 3 disposed between the two electrodes 190 and 270 functions as dielectric of the LC capacitor CLC. The pixel electrode 190 is connected to the switching element Q, and the common electrode 270 is supplied with a common voltage Vcom and covers an entire surface of the upper panel 200. Unlike Fig. 2, the common electrode 270 may be provided on the lower panel 100, and both electrodes 190 and 270 may have shapes of bars or stripes.

The storage capacitor CST is an auxiliary capacitor for the LC capacitor CLC. The storage capacitor CST includes the pixel electrode 190 and a separate signal line, which is provided on the lower panel 100, overlaps the pixel electrode 190 via an insulator, and is supplied with a predetermined voltage such as the common voltage Vcom. Alternatively, the storage

capacitor CST includes the pixel electrode 190 and an adjacent gate line called a previous gate line, which overlaps the pixel electrode 190 via an insulator.

For color display, each subpixel uniquely represents one of primary colors (i.e., spatial division) or each subpixel sequentially represents the primary colors in turn (i.e., temporal division) such that spatial or temporal sum of the primary colors are recognized as a desired color. Fig. 2 shows an example of the spatial division that each subpixel includes a color filter 230 representing one of the primary colors in an area of the upper panel 200 facing the pixel electrode 190. Alternatively, the color filter 230 is provided on or under the pixel electrode 190 on the lower panel 100.

An example of a set of the primary colors includes red, green, and blue colors or complementary colors thereof, i.e., cyan, magenta, and yellow colors.

The above-described six colors is referred to as six primary colors hereinafter, and red, green and blue colors are referred to as first three primary colors, while cyan, magenta, and yellow colors are referred to as second three primary colors. The six primary colors preferably satisfy the positions at the color coordinates defined by TABLE.

Red	Red, Redish-Orange
Green	Green
Blue	Blue, Purplish Blue, Bluish-Purple
Cyan	Bluish-Green, Blue-Green, Greenish Blue
Magenta	Red-Purple, Redish-Purple, Purplish-Pink, Redish-Purple, Purple
Yellow	Yellow, Orange, Yellowish-Orange, Greenish-Yellow, Yellow-Green

TABLE is quoted from Billmeyer and Saltzman, Principles of Color Technology, 2nd Ed., John Wiley & Sons, Inc., pp.50.

Hereinafter, a subpixel is referred to as red, green, blue, cyan, magenta, and yellow subpixel depending on the color represented by the subpixel and the red, green, blue, cyan, magenta, and yellow subpixels are denoted by reference characters R, G, B, C, M, and Y, respectively, which also denote the image signals for the colors.

Fig. 3a-3c show arrangements of six six-color subpixels of an LCD according to embodiments of the present invention.

It is noted that a set of red, green, blue, cyan, magenta, and yellow subpixels form a pixel that is a basic unit for displaying an image.

Referring to Fig. 3a-3c, the subpixels forming a pixel are arranged in a 2X3 matrix that includes a first row including red, green and blue subpixels R, G, and B and a second row including cyan, magenta, and yellow subpixels C, M and Y.

Each pair of the red and the cyan subpixels R and C, the green and the magenta subpixels G and M, and the blue and the yellow subpixels B and Y, which have a complementary relation, are adjacent to each other. Accordingly, the addition of the three colors represented by the subpixels in any row and the addition of the two colors represented by the subpixels in any column row yield an achromatic color.

Disposed at centers in the two rows are the green and the magenta subpixels G and M shown in Fig. 3a, the red and the cyan subpixels R and C shown in Fig. 3b, and the blue and the yellow subpixels B and Y shown in Fig. 3c.

These arrangements prevent color error that a color is recognized near

transverse and longitudinal edges of a character displayed on an LCD, which will be described in detail.

One or more polarizers (not shown) are attached to at least one of the panels 100 and 200.

Referring to Fig. 1 again, the gray voltage generator 800 generates two sets of a plurality of gray voltages related to the transmittance of the subpixels. The gray voltages in one set have a positive polarity with respect to the common voltage Vcom, while those in the other set have a negative polarity with respect to the common voltage Vcom.

The gate driver 400 is connected to the gate lines G1-Gn of the panel assembly 300 and synthesizes the gate-on voltage Von and the gate-off voltage Voff from an external device to generate gate signals for application to the gate lines G1-Gn.

The data driver 500 is connected to the data lines D1-Dm of the panel assembly 300 and applies data voltages, which are selected from the gray voltages supplied from the gray voltage generator 800, to the data lines D1-Dm.

The drivers 400 and 500 may include at least one integrated circuit (IC) chip mounted on the panel assembly 300 or on a flexible printed circuit (FPC) film in a tape carrier package (TCP) type, which are attached to the LC panel assembly 300. Alternately, the drivers 400 and 500 may be integrated into the panel assembly 300 along with the display signal lines G1-Gn and D1-Dm and the TFT switching elements Q.

The signal controller 600 controls the gate driver 400 and the gate driver 500.

Now, the operation of the above-described LCD will be described in detail.

The signal controller 600 is supplied with input three-color image signals R, G and B and input control signals controlling the display thereof such as a vertical synchronization signal Vsync, a horizontal synchronization signal Hsync, a main clock MCLK, and a data enable signal DE, from an external graphics controller (not shown). After generating gate control signals CONT1 and data control signals CONT2 and converting and processing the input image signals R, G and B into six-color image signals R', G', B', C, M and Y suitable for the operation of the panel assembly 300 on the basis of the input control signals and the input image signals R, G and B, the signal controller 600 transmits the gate control signals CONT1 to the gate driver 400, and the processed image signals R', G', B', C, M and Y and the data control signals CONT2 to the data driver 500.

The gate control signals CONT1 include a scanning start signal STV for instructing to start scanning and at least a clock signal for controlling the output time of the gate-on voltage Von. The gate control signals CONT1 may further include an output enable signal OE for defining the duration of the gate-on voltage Von.

The data control signals CONT2 include a horizontal synchronization start signal STH for informing of start of data transmission for a group of subpixels, a load signal LOAD for instructing to apply the data voltages to the data lines D1-Dm, and a data clock signal HCLK. The data control signal CONT2 may further include an inversion signal RVS for reversing the polarity of

the data voltages (with respect to the common voltage Vcom).

Responsive to the data control signals CONT2 from the signal controller 600, the data driver 500 receives a packet of the image data R', G', B', C, M and Y for the group of subpixels from the signal controller 600, converts the image data R', G', B', C, M and Y into analog data voltages selected from the gray voltages supplied from the gray voltage generator 800, and applies the data voltages to the data lines D1-Dm.

The gate driver 400 applies the gate-on voltage Von to the gate line G1-Gn in response to the gate control signals CONT1 from the signal controller 600, thereby turning on the switching elements Q connected thereto. The data voltages applied to the data lines D1-Dm are supplied to the subpixels through the activated switching elements Q.

The difference between the data voltage and the common voltage Vcom is represented as a voltage across the LC capacitor CLC, which is referred to as a subpixel voltage. The LC molecules in the LC capacitor CLC have orientations depending on the magnitude of the subpixel voltage, and the molecular orientations determine the polarization of light passing through the LC layer 3. The polarizer(s) converts the light polarization into the light transmittance.

By repeating this procedure by a unit of the horizontal period (which is denoted by 1H and equal to one period of the horizontal synchronization signal Hsync and the data enable signal DE), all gate lines G1-Gn are sequentially supplied with the gate-on voltage Von during a frame, thereby applying the data voltages to all subpixels. When the next frame starts after finishing one frame,

the inversion control signal RVS applied to the data driver 500 is controlled such that the polarity of the data voltages is reversed (which is referred to as frame inversion). The inversion control signal RVS may be also controlled such that the polarity of the data voltages flowing in a data line in one frame are reversed (for example, line inversion and dot inversion), or the polarity of the data voltages in one packet are reversed (for example, column inversion and dot inversion).

The experiments obtained giant six-color subpixels using a conventional three-color LCD, each giant subpixel having the same size as a pixel including three original subpixels. For example, a giant red, green, or blue subpixel was realized by activating a subpixel representing a color corresponding thereto and inactivating other two subpixels to be dark. Similarly, a giant cyan, magenta, or yellow subpixel was realized by inactivating a subpixel representing a color complementary thereto and activating remaining two subpixels. The six giant subpixels form a giant pixel and the giant subpixels and the giant pixels will be merely referred to as subpixels and pixels unless it causes confusion.

To arrange the subpixels in order of the luminance, it was the yellow subpixel Y, the cyan subpixel C, the green subpixel G, the red subpixel R, the magenta subpixel M, and the blue subpixel B.

In addition, two cyan subpixels C having different luminance was manufactured and the lower one was one thirds of the luminance of the green subpixel G. A cyan subpixel having higher luminance will be referred to as a brighter cyan subpixel, while that having lower luminance will be referred to as a darker cyan subpixel. The different luminance of the cyan subpixel C was

resulted from the different techniques for implementing a cyan color filter, one providing a single filter layer passing cyan light while the other providing two filter layers respectively passing green and blue lights. The latter generated higher luminance than the former.

First, a white longitudinal line having a width substantially equal to the width of a pixel was displayed on a dark background for various subpixel arrangements including those shown in Fig. 3a-3c. The arrangements shown in Fig. 3a-3c, where the addition of the colors in each row make an achromatic color and adjacent two colors in each column have a complementary relation, showed a clean edge of the white line, while other arrangements showed a color near the edges of the white line.

Next, white oblique lines were displayed on a dark background for the arrangements shown in Fig. 3a-3c. The oblique lines had a width substantially equal to the width of a pixel and had opposite gradients, one having positive gradient to extend from the lower left to the upper right or vice versa (referred to as positive line hereinafter) and the other having negative gradient to extend from the upper left to the lower right (referred to as negative line hereinafter). The inclination angle of the oblique lines was about 45 degrees.

In this experiment, a green dot was observed at an upper portion of the positive line for the arrangement shown in Fig. 3c.

When employing a brighter cyan subpixel, the two oblique lines for the arrangement shown in Fig. 3b was observed to have slightly different widths, but it is not an eyesore. On the other hand, the arrangement shown in Fig. 3a exhibited no such a thing.

When employing a darker cyan subpixel, the two oblique lines for the arrangement shown in Fig. 3b was also observed to have slightly different widths, but it is also not an eyesore. The oblique lines for the arrangement shown in Fig. 3a were observed to smoothly proceed, but those for the arrangement shown in Fig. 3a were observed not to be continuous.

Finally, picture images displayed by the arrangements shown in Fig. 3a and Fig. 3b were observed to be excellent.

The above-described experimental results will be analyzed in detail with reference to Figs. 4a-5b.

Figs. 4a and 5a illustrate oblique lines displayed by the subpixel arrangement shown in Fig. 3a, and Figs. 4b, 4c and 5b illustrate oblique lines displayed by the subpixel arrangement shown in Fig. 3b.

First, it is noted that human eyes may recognize a pattern determined by the luminance of the subpixels when displaying a straight line or a circle.

The arrangement shown in Fig. 3c may separate outer colors with respect to the blue subpixel B disposed at the center since the blue subpixel B has the lowest luminance. In particular, when displaying a positive line, the darkest, blue subpixel B and the next darkest, magenta subpixel M are arranged in parallel to the oblique line, and thus a dark band formed by the darkest subpixels B and M separates the green subpixel G disposed at an upper left position from the yellow, cyan, and red subpixels Y, C and R. Accordingly, the yellow, cyan, and red subpixels Y, C and R may be recognized as portions of the oblique line, while the green subpixel G may be separated to be recognized as a green spot. This is applicable for both brighter and darker

cyan subpixels C.

Next, a case employing a brighter cyan subpixel will be described.

Referring to Fig. 4a, the arrangement shown in Fig. 3a symmetrically arranges three brightest subpixels, i.e., green, cyan, and yellow subpixels G, C and Y, which are enclosed by circles. Accordingly, the width of the positive line, which is determined by the green and the yellow subpixels G and Y as denoted by a reference numeral 41, is almost equal to the width of the negative line that is determined by the green and the cyan subpixels G and C as denoted by a reference numeral 42.

On the contrary, the green, cyan, and yellow subpixels G, C and Y in the arrangement shown in Fig. 3b are obliquely arranged as shown in Fig. 4b. Therefore, the width of the positive line, which is determined by the green and yellow subpixels G and Y as denoted by a reference numeral 43, is larger than the width of the negative line that is determined by the cyan and yellow subpixels C and Y as denoted by a reference numeral 44.

Next, it will be described a case that the cyan subpixel C has a luminance one thirds of the luminance of the green subpixel G, which is disposed between the luminance of the red subpixel R and the luminance of the magenta subpixel M.

Referring to Fig. 4c, since the cyan subpixel C is not a brightest subpixel any more, the width 46 of the negative line is determined by the green and yellow subpixels G and Y to be reduced compared with that shown in Fig. 4b.

Figs. 5a and 5b show two pixels arranged along a negative line.

Referring to Fig. 5a, a straight line passing through the centers of the green subpixel G and the yellow subpixel Y in the arrangement shown in Fig. 3a is somewhat offset from a 45-degree negative oblique line. Therefore, the connection of the centers of the green and yellow subpixels G and Y may not form a perfectly straight line and thus a displayed oblique line may appear coarse.

However, a straight line passing through the centers of the green subpixel G and the yellow subpixel Y in the arrangement shown in Fig. 3b is nearly a 45-degree negative oblique line as shown in Fig. 5b. Therefore, the connection of the centers of the green and yellow subpixels G and Y may have a smooth profile.

Figs. 6a-6h and 7a-7h show subpixel arrangements modified from those shown in Fig. 3a and 3b, respectively.

Referring to Figs. 6a-6h and 7a-7h, a set of first primary color subpixels, i.e., red, green, and blue subpixels R, G, and B are disposed in a row or a column, and thus a set of second primary color subpixels, i.e., cyan, magenta, and yellow subpixels C, M and Y are disposed in a row or a column. In addition, the subpixels having a complementary relation are disposed adjacent to each other.

The arrangements shown in Figs. 6a-6h place the green subpixel G at the center, while it places the cyan and yellow subpixels C and Y at the sides.

The arrangements shown in Figs. 6a to 6d have shape of 2X3 matrix that includes a first row including the first primary color subpixels and a second row including the second primary color subpixels as shown in Figs. 6a and 6b or

includes first row including the second primary color subpixels and a second row including the first primary color subpixels as shown in Figs. 6c and 6d. The arrangements shown in Figs. 6a and 6c place the red and cyan subpixels R and C at the left side, which those shown in Figs. 6b and 6d place the red and cyan subpixels R and C at the right ride.

The arrangements shown in Figs. 6e to 6h are transposes of the arrangements shown in Figs. 6a to 6d in terms of matrix.

The arrangements shown in Figs. 7a-7h place the green subpixel G and the yellow subpixel Y in a diagonal.

The arrangements shown in Figs. 7a to 7d have shape of 23 matrix that includes a first row including the first primary color subpixels and a second row including the second primary color subpixels as shown in Figs. 7a and 7b or includes first row including the second primary color subpixels and a second row including the first primary color subpixels as shown in Figs. 7c and 7d. The arrangements shown in Figs. 7a and 7c place the green subpixel G at the left side, which those shown in Figs. 7b and 7d place the green subpixel G at the right ride.

The arrangements shown in Figs. 7e to 7h are transposes of the arrangements shown in Figs. 7a to 7d in terms of matrix.

The magenta subpixel may be substituted with a white subpixel for increasing the luminance, which will be described in detail.

Describing the reason why the magenta is replaced, red, green and blue are primary colors of light and very significant for the color range and the color representation, cyan color is dominantly contribute to the expansion of the

includes first row including the second primary color subpixels and a second row including the first primary color subpixels as shown in Figs. 6c and 6d. The arrangements shown in Figs. 6a and 6c place the red and cyan subpixels R and C at the left side, which those shown in Figs. 6b and 6d place the red and cyan subpixels R and C at the right ride.

The arrangements shown in Figs. 6e to 6h are transposes of the arrangements shown in Figs. 6a to 6d in terms of matrix.

The arrangements shown in Figs. 7a-7h place the green subpixel G and the yellow subpixel Y in a diagonal.

The arrangements shown in Figs. 7a to 7d have shape of 23 matrix that includes a first row including the first primary color subpixels and a second row including the second primary color subpixels as shown in Figs. 7a and 7b or includes first row including the second primary color subpixels and a second row including the first primary color subpixels as shown in Figs. 7c and 7d. The arrangements shown in Figs. 7a and 7c place the green subpixel G at the left side, which those shown in Figs. 7b and 7d place the green subpixel G at the right ride.

The arrangements shown in Figs. 7e to 7h are transposes of the arrangements shown in Figs. 7a to 7d in terms of matrix.

The magenta subpixel may be substituted with a white subpixel for increasing the luminance, which will be described in detail.

Describing the reason why the magenta is replaced, red, green and blue are primary colors of light and very significant for the color range and the color representation, cyan color is dominantly contribute to the expansion of the

color range, and yellow is the most sensitive color to human eyes, thereby making dominant effect on the visibility.

Figs. 8a-8d show subpixel arrangements according to other embodiments of the present invention.

Referring to Figs. 8a-8d, the subpixels forming a pixel are arranged in a 23 matrix that includes a first row including red, green and blue subpixels R, G, and B and a second row including cyan, white, and yellow subpixels C, W and Y. The 23 matrix is approximately square and each subpixel may be square.

The subpixels R, B, C, and Y are arranged such that two complementary colors are adjacent to each other. That is, each pair of the red and the cyan subpixels R and C and the blue and the yellow subpixels B and Y, which have a complementary relation, are adjacent to each other. In addition, the green and the white subpixels G and W are adjacent to each other although they are not complementary.

The blue and yellow subpixels B and Y are disposed at the sides in the two rows for all the arrangements shown in Figs. 8a to 8d. The green and the white subpixels G and W are disposed at the center in Figs. 8a and 8c, while they are disposed at the right in Figs. 8b and 8d.

Some experiments using giant subpixels were conducted for proving the appropriateness of the subpixel arrangements.

To arrange the subpixels in order of the luminance, it was the white subpixel W, the yellow subpixel Y, the green subpixel G, the red and cyan subpixel R and C, and the blue subpixel B.

First, white oblique lines having positive and negative gradients were

displayed on a dark background for the arrangements shown in Figs. 8a and 8b. The oblique lines had a width substantially equal to the width of a pixel and inclination angle of the oblique lines was about 45 degrees. Since the experimental results for the arrangements shown in Figs. 8c and 8d can be easily expected from the results for the arrangements shown in Figs. 8a and 8b, the experiments for Figs. 8c and 8d were omitted.

In this experiment, the two oblique lines for the arrangement shown in Figs. 8a and 8b was observed to have slightly different widths, but it is not an eyesore. In addition, picture images displayed by the arrangements were observed to be excellent.

The above-described experimental results will be analyzed in detail with reference to Figs. 9a and 9b.

Figs. 9a and 9b illustrate oblique lines displayed by the subpixel arrangement shown in Figs. 8a and 8b.

Referring to Fig. 9a, the arrangement shown in Figs. 8a arranges three brightest subpixels, i.e., white, yellow, and green subpixels W, Y and G, which are enclosed by circles. Accordingly, the width of the positive line, which is determined by the green and the white subpixels G and W as denoted by a reference numeral 61, is almost equal to the width of the negative line that is determined by the green and the yellow subpixels G and Y as denoted by a reference numeral 62.

On the contrary, the green, white, and yellow subpixels G, W and Y in the arrangement shown in Figs. 8b are obliquely arranged as shown in Fig. 9b. Therefore, the width of the positive line, which is determined by the green or

yellow subpixel G or Y and the white subpixel W as denoted by a reference numeral 63, is larger than the width of the negative line that is determined by the green and yellow subpixels G and Y as denoted by a reference numeral 64.

The arrangements in a form of 2X3 matrix can be transposed into 3X2 matrix like those shown in Figs. 6e-6h and 7e-7h.

Fig. 10 shows the luminance variation depending on the variation of magenta.

The first column denoted as Magenta indicates the thickness of the color filter 230 for magenta represented as microns. The magenta color becomes more as the color filter becomes thick. The second and third columns indicate color coordinates x and y and the last column denoted as LUM indicates the luminance.

The luminance is a percentage value with respect to a luminance for a 2-micron thickness of the magenta filter. The luminance is increased up to about 30% as the amount of the magenta is decreased, that is, the thickness of the magenta color filter is decreased.

The above description may be applicable to any display device such as a light emitting diode or plasma display panel.

[EFFECT OF THE INVENTION]

The six-color subpixel arrangement may prevent the color error that appears near edges of the small characters and can reproduce an image that approaches the original image. The substitution of magenta with white in the above-described six-color arrangement may increase the luminance to increase the image quality.

Although preferred embodiments of the present invention have been described in detail hereinabove, it should be clearly understood that many variations and/or modifications of the basic inventive concepts herein taught which may appear to those skilled in the present art will still fall within the spirit and scope of the present invention, as defined in the appended claims.

[CLAIMS]

1. A display device comprising:

a plurality of pixel arranged in matrix, each pixel including first and second sets of three primary color subpixels,

wherein the subpixels are arranges so that two subpixels having complementary relation is adjacent to each other.

2. The device of claim 1, wherein the subpixels are arranged in a 2X3 matrix or a 3X2 matrix.

3. The device of claim 2, wherein the first set of three primary color subpixels are arranged in a row or a column, and the second set of three primary color subpixels are arranged in a row or a column.

4. The device of claim 3, wherein a subpixel having the lowest luminance is disposed at a side.

5. The device of claim 3 or 4, wherein three subpixels having relatively high luminance are distributed over different rows or columns.

6. The device of claim 5, wherein the three high-luminance subpixels are distributed over two rows or two columns.

7. The device of claim 6, wherein the three high-luminance subpixels are arranged symmetrically in a row or column direction.

8. The device of claim 3 or 4, wherein two subpixels having relatively high luminance are arranged in a diagonal.

9. The device of claim 1, wherein the first or the second set of three primary color subpixels include a white subpixel.

10. The device of claim 1, wherein the first set of three primary color

subpixels include red, green and blue subpixels, and the second set of three primary color subpixels include cyan, magenta, and yellow subpixels.

11. The device of claim 9, wherein the first set of three primary color subpixels include red, green and blue subpixels, and the second set of three primary color subpixels include cyan, white, and yellow subpixels.

12. The device of claim 9, wherein the subpixels are arranged in a 2X3 matrix or a 3X2 matrix.

13. The device of claim 12, wherein the first set of three primary color subpixels are arranged in a row or a column, and the second set of three primary color subpixels are arranged in a row or a column.

14. The device of claim 13, wherein the blue subpixel is disposed at a side.

~~15. The device of claim 14,~~ wherein the green subpixel is disposed at a center.

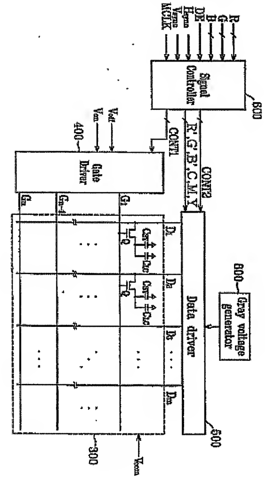
16. The device of claim 15, wherein the green, cyan, and yellow subpixels have luminance higher than other subpixels.

17. The device of claim 14, wherein the green subpixel is disposed at a side.

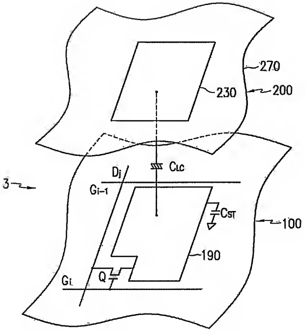
18. The device of claim 17, wherein the green and yellow subpixels have luminance higher than other subpixels.

[DRAWINGS]

[FIG. 1]



[FIG. 2]



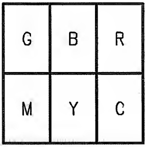
[FIG. 3a]

R	G	B
C	M	Y

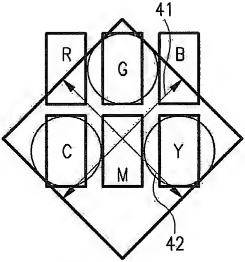
[FIG. 3b]

G	R	B
M	C	Y

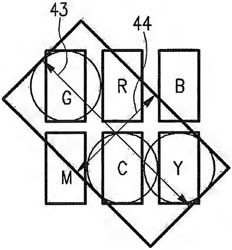
[FIG. 3c]



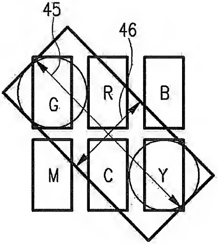
[FIG. 4a]



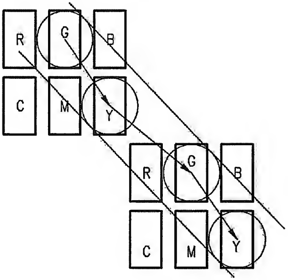
[FIG. 4b]



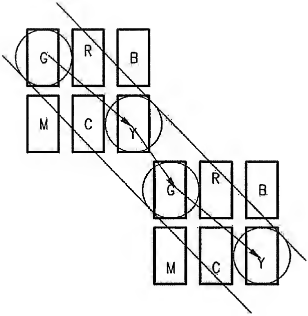
[FIG. 4c]



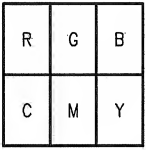
[FIG. 5a]



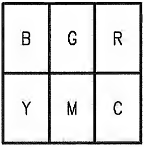
[FIG. 5b]



[FIG. 6a]



[FIG. 6b]



[FIG. 6c]

C	M	Y
R	G	B

[FIG. 6d]

Y	M	C
B	G	R

[FIG. 6e]

R	C
G	M
B	Y

[FIG. 6f]

B	Y
G	M
R	C

[FIG. 6g]

C	R
M	G
Y	B

[FIG. 6h]

Y	B
M	G
C	R

[FIG. 7a]

G	R	B
M	C	Y

[FIG. 7b]

B	R	G
Y	C	M

[FIG. 7c]

M	C	Y
G	R	B

[FIG. 7d]

Y	C	M
B	R	G

[FIG. 7e]

G	M
R	C
B	Y

[FIG. 7f]

B	Y
R	C
G	M

[FIG. 7g]

M	G
C	R
Y	B

[FIG. 7h]

Y	B
C	R
M	G

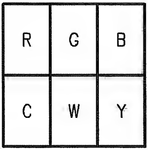
[FIG. 8a]

B	G	R
Y	W	C

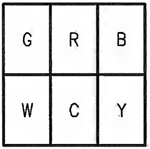
[FIG. 8b]

B	R	G
Y	C	W

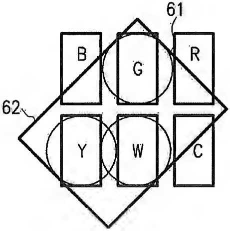
[FIG. 8c]



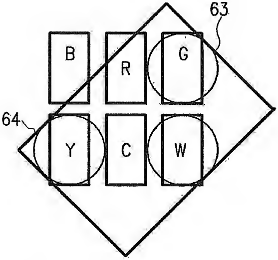
[FIG. 8d]



[FIG. 9a]



[FIG. 9b]



[FIG. 10]

Magenta	*Coord. x*	*Coord. y*	*LUM*
2	0.327038285	0.18711	100.0
1.8	0.3246111231	0.193028	101.2
1.6	0.322195168	0.199955	102.6
1.4	0.31979066	0.208016	104.3
0.2	0.317398796	0.217345	106.3
1	0.315021374	0.22807	108.6
0.8	0.312661088	0.240314	111.5
0.6	0.310321722	0.254181	115.0
0.4	0.308008316	0.269747	1119.1
0.2	0.305727265	0.287048	124.2
0	0.30348633	0.306066	130.4